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Global uncertainty assessment for hydrological model output based on the analysis of model errors: a multiple regression approach

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A statistically based approach for assessing the global uncertainty of the output of a generic hydrological model is proposed. Accordingly, the probability distribution of the hydrological model error is inferred through a non linear multiple regression approach, depending on an arbitrary number of selected conditioning variables. These may include the current and previous model output as well as internal state variables of the model. The purpose is to indirectly relate the model error to the sources of uncertainty, through the conditioning variables. The method can be applied to any model of arbitrary complexity, included distributed approaches. The probability distribution of the model error is derived in the Gaussian space, through a meta-Gaussian approach. The normal quantile transform is applied in order to make the marginal probability distribution of the model error and the conditioning variables Gaussian. Then the above marginal probability distributions are related through the multivariate Gaussian distribution, whose parameters are estimated via multiple regression. Application of the inverse of the normal quantile transform allows the user to derive the confidence limits of the model output for an assigned significance level. The proposed technique is valid under statistical assumptions, that are essentially those conditioning the validity of the multiple regression in the Gaussian space. An original approach, that will be discussed in detail, is proposed in order to resolve the problem caused by the heteroscedasticity of the hydrological model error, which often compromises the validity of the above multiple regression. Statistical tests are proposed and discussed in order to test the reliability of the estimated confidence limits. Applications are shown in validation mode, that refer to a rainfall-runoff model applied to an Italian river basin. The above proposed technique can be applied in an equifinality context also.